

WHAT IS CLAIMED IS:

1                    1.        A method of material surface treatment in a substantially  
2 downstream position of a plasma source, the method comprising generating a plasma  
3 discharge including a gas-C, the gas-C comprising a Gas-A molecule containing  
4 essentially hydrogen as an element and a Gas-B containing essentially a halogen and/or a  
5 halide; wherein said plasma discharge is substantially free from an oxygen bearing  
6 species.

1                    2.        The method of claim 1 further comprising injecting a Gas-D in the  
2 downstream of the plasma of Gas-C and setting objective surface in downstream of the  
3 Gas-D injection.

1                    3.        The method of claim 1, wherein using the molecule and/or  
2 compound of chlorine, bromine and/or iodine as Gas-B.

1                    4.        The method of claim 2, wherein using the molecule and/or  
2 compound of chlorine, bromine and/or iodine as Gas-B.

1                    5.        The method of claim 4, wherein using the molecule and/or  
2 compound of chlorine, bromine and/or iodine as Gas-B does not containing oxygen atom.

1                    6.        The method of claim 5, wherein using the molecule of chlorine,  
2 hydrogen chloride, bromine, or hydrogen bromide as Gas-B.

1                    7.        The method of claim 5, wherein using the molecule of chlorine,  
2 hydrogen chloride, bromine, or hydrogen bromide as Gas-B.

1                    8.        The method of claim 6, wherein the flow rate of the molecule of  
2 hydrogen-chloride or hydrogen-bromide as Gas-B in total Gas-C flow is defined as the  
3 ratio of amount of hydrogen atom in Gas-B to that in Gas-A is larger than 1/480.

1                    9.        The method of claim 2, wherein gas containing silicon as its  
2 element is used as Gas-D.

1                    10.       The method of claim 2, wherein gas containing carbon as its  
2 element is used as Gas-D.

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1 11. The method of claim 2, wherein gas containing fluorine as its  
2 element is used as Gas-D.

1 12. An apparatus for treating material surface downstream of a plasma  
2 source, the apparatus comprising:  
3 a treatment chamber;  
4 a plasma discharge area to generate a plasma comprising a mixture of a  
5 gas composed of molecules containing hydrogen atom as an element and a gas containing  
6 molecules and/or compound of chlorine, bromine, and/or iodine, the plasma discharge  
7 connecting with the treatment chamber, the treatment chamber being downstream from  
8 the plasma discharge area and the treatment area being maintained in a vacuum;  
9 a stage for setting an object in the treatment area; and  
10 an inner wall surface of the discharged area, the inner wall surface  
11 comprising a silicon nitride material.

1 13. The apparatus in claim 11, wherein the at least a gas inlet is set  
2 between the plasma discharge area and the upstream of the stage.

1 14. The apparatus in claim 11, wherein at least a part of the plasma  
2 discharge area is composed of silicon nitride or quartz whose surface exposed to the  
3 plasma is covered by silicon nitride.

1 15. The apparatus in claim 12, wherein at least a part of the plasma  
2 discharge area is composed of silicon nitride or quartz whose surface exposed to the  
3 plasma is covered by silicon nitride.

1 16. An apparatus for treating a silicon wafer, the apparatus comprising:  
2 a code directed to transferring a silicon wafer comprising an upper surface  
3 in a vacuum chamber using a transferring means, the silicon wafer including a layer of  
4 native oxide overlying the upper surface of the silicon wafer;  
5 a code directed to switching a controller for applying a gaseous plasma  
6 discharge on the layer of native oxide to substantially remove the native oxide without  
7 physically damaging the surface of the silicon wafer;  
8 wherein the gaseous plasma discharge is derived from an upstream plasma  
9 source from the vacuum chamber, said upstream source comprising a hydrogen bearing

10 species and a halogen bearing species; wherein the upstream plasma source being  
11 substantially free from an oxygen bearing species.

1                    17.    The apparatus of claim 16 wherein the gaseous plasma discharge is  
2    substantially free from an oxygen bearing species.

1                    18.     The apparatus of claim 16 wherein the silicon wafer is disposed on  
2     a stage, the stage being surrounded by an inner surface coated with a silicon nitride  
3     compound.

1                    19.      The apparatus of claim 16 wherein the upstream plasma source and  
2      the stage is positioned to each other to substantially eliminate any physical influence of  
3      the gaseous plasma discharge.

1                    20.     The apparatus of claim 19 wherein the gaseous plasma discharge is  
2 maintained in a silicon nitride material in the vacuum chamber.

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